Heavy Flavour Production at HERA

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Abstract

Recent measurements of Charm and Beauty production at HERA are described. The charm results are well described by NLO QCD calculations with a somewhat better description in the CCFM than in the DGLAP evolution schemes. However, the Beauty results in both photoproduction and in deep inelastic scattering (DIS) are poorly described by such calculations.

1 Introduction

Photon gluon fusion in leading order (LO) was first shown to be the mechanism governing charm production in deep inelastic scattering (DIS) by the EMC [1, 2] at fixed target energies. At the higher energies at HERA higher order corrections become significant. In this paper the most recent HERA data on charm and beauty production in both DIS and photoproduction are compared to such computations at next to leading order (NLO).

2 Charm Production.

New results on the differential cross sections for charm production have been announced by the H1 collaboration [3, 4]. The data are compared to the predictions of two Monte Carlo models which are based on NLO QCD. The HVQDIS [5] Monte Carlo model is based on the evolution at NLO of the momentum densities of the light quarks and the gluon of the proton in the DGLAP evolution scheme. The heavy quarks are then produced perturbatively by the photon gluon fusion mechanism. The CASCADE Monte Carlo uses a NLO calculation based on a solution of the CCFM equation [6], which becomes BFKL-like as $x \to 0$. It is found that the CASCADE model gives a better representation of the data than the HVQDIS model both in shape and normalisation.

Both ZEUS and H1 have produced measurements of the charm contribution to the proton structure function F_2. The ZEUS collaboration has

published measurements from inclusive D^* production [7] and announced recently impressive measurements [8] from inclusive electron production where the electron comes from semileptonic charm decay. The latter measurements have extended the Q^2 range of the data up to 565 GeV^2 and indicate that charm constitutes $\sim$40% of the proton structure function F_2 at this Q^2 and $x \sim 0.01$.

The H1 collaboration has announced its measurements from inclusive D^* production [3, 4]. The values of F_2^c were extracted using both the CASCADE and HVQDIS models to estimate the contribution from the unmeasurable region (about 70% of all the phase space). There are systematic shifts between the values using the different models to extrapolate the data into the full phase space [3, 4]. The data points extracted using HVQDIS tend to rise more steeply as x decreases than those using CASCADE. The agreement of the both models and the data is reasonable but not perfect. As with the differential cross sections the CASCADE model shows better agreement with the data than the HVQDIS model, each extracted within the framework of its own model.

The data show that at these values of x and Q^2 charm contributes a significant fraction to the inclusive structure function, F_2, of the proton. The data show a rapid rise with Q^2 at fixed x. In fact roughly half of the scaling violations seen in the inclusive structure function F_2 in the x range $.0002 < x < .002$ at the central Q^2 of the measurements can be attributed to charm production.

3 Beauty Production

Both ZEUS and H1 have published measurements of the photoproduction ($Q^2 \sim 0$) cross section for Beauty [9, 10, 11]. The ZEUS experiment [9] detects the electrons produced from semileptonic b decay to measure the cross section, obtaining the background from pair conversions from light quark fragmentation using the data. The H1 experiment detects muons from semileptonic b decay [10] measuring the background from muons from the decay and punch through from light hadrons from the data. In a second analysis [11] the silicon vertex detector installed in H1 has been used to detect the b decays using the lifetime of the B meson which produces a finite impact parameter of the decay products at the primary vertex. The lifetime

method has also been applied by H1 to produce the first measurement of the b production cross section in DIS in the range $2 < Q^2 < 100$ GeV^2 [13]. The two H1 measured photoproduction cross sections are in good agreement but they lie significantly (by a factor $\sim$2) above the value of a QCD calculation at NLO [12]. The ZEUS photoproduction result is also a similar amount higher than the predictions of this model. The H1 DIS cross section is also found to be significantly higher than a NLO calculation based on the HVQDIS program [5].

4 Conclusions

Charm production in DIS shows reasonable agreement with models based on NLO QCD. However, the agreement with the predictions of a Monte Carlo program based on the CCFM equation is better than with one based on DGLAP evolution. Perhaps this is an indication of the onset of BFKL behaviour. The measured Beauty cross sections are found to be larger than the predictions of NLO QCD. It is very puzzling that charm production should be quite well reproduced by NLO QCD, top production at the TEVATRON is similarly well reproduced by NLO QCD [14] yet beauty production is not well reproduced by such calculations either at HERA or at the TEVATRON [15]. We heard at this conference an explanation for this phenomenon in which physics beyond the standard model is invoked [16].

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